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Eliciting Expert Opinion in Acquisition Cost and Schedule Estimating

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Eliciting Expert Opinion in Acquisition Cost and Schedule Estimating

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Background



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- Despite analytics push, expert opinion will likely remain relevant
 - Limited ACAT II/III data collection...databases focus on ACAT I data
 - New technologies and production methods
 - Parametric models often require subjective inputs (e.g. estimated lines of code)
- Why is this a problem?
 - Formal cost analyst training/education focuses on parametric modeling, underemphasizes elicitation techniques
 - No structured elicitation model in DoD:
 - “[E]licitation methodologies are largely ad hoc...seldom based on elicitation literature” (Galway, 2007)
 - Poor Documentation & Unstated Assumptions within DoD elicitations
 - “It is especially hard to go back to finished projects and get historical information about the elicitations that were done.” (Galway, 2007)
 - Inconsistent adjustment for expert overconfidence



Research Questions



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- Research Questions

- Q1. Does research support the Joint Agency Cost Schedule Risk Uncertainty Handbook (JA CSRUH) heuristic of adding 30% additional uncertainty to the expert's range?
- Q2. Does a formal elicitation model exist that could be adapted for DoD cost and schedule estimating?



Q1: Overconfidence Heuristic



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- Per JA CSRUH, add 30% additional uncertainty to expert's low/high bounds
- Heuristic based on Capen (1976); shortcomings:
 - A single study with 1,200 participants x 10 questions each: 12,000 observations
 - Research is 40+ years old
 - Capen quizzed petroleum engineers with encyclopedia questions
- Does contemporary research exist that supports/refutes Capen's finding?
Inclusion criteria:
 - Must utilize experts with industry experience (not undergraduate college students)
 - Must involve business or engineering domain (closest equiv. to DoD acquisition)
 - Experts must estimate continuous values (not probabilities of event)

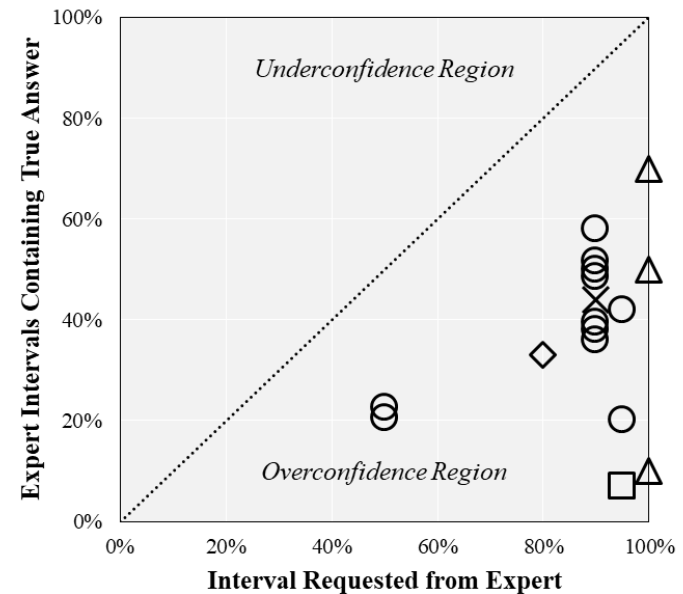


Q1: Overconfidence Heuristic

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Author (Year)	Interval Requested	Intervals Containing Truth	Number of Predictions	Expert	Estimating Task
<u>Russo & Schoemaker (1992)</u>					
Advertising 1	90%	39%	750	Corporate Managers	Advertising Industry Knowledge
Advertising 2	50%	22%	750	Corporate Managers	Advertising Industry Knowledge
Computers 1	95%	20%	1,290	Corporate Managers	Computer Industry Knowledge
Computers 2	95%	42%	1,290	Corporate Managers	Computer Firm Knowledge
Data Processing 1	90%	58%	252	Corporate Managers	Data Processing Industry Knowledge
Data Processing 2	90%	38%	261	Corporate Managers	General Business Knowledge
Money Management 1	90%	50%	480	Corporate Managers	Financial Industry Knowledge
Petroleum 1	90%	50%	850	Corporate Managers	Petroleum Industry and Firm Knowledge
Petroleum 2	50%	21%	850	Corporate Managers	Petroleum Industry and Firm Knowledge
Pharmaceutical 1	90%	51%	390	Corporate Managers	Pharmaceutical Firm Knowledge
Security Analysis 1	90%	36%	497	Corporate Managers	Security Industry Knowledge
<u>McKenzie et al. (2008)</u>	90%	44%	1,720	IT Professionals	IT Industry Knowledge
<u>Ben-David et al. (2013)</u>	80%	33%	11,600	Chief Financial Officers	Stock Market Return (S&P 500)
<u>Goldenson & Stoddard (2013)</u>					
Battery 1	100%	10%	140	Graduate Students	Software Development Effort
Battery 2	100%	50%	80	Graduate Students	Software Development Effort
Battery 3	100%	70%	70	Graduate Students	Software Development Effort
<u>Bar-Yosef & Venezia (2014)</u>	95%	7%	30	Brokerage Analysts	Financial Forecasts

○ Russo and Schoemaker (1992) ✕ McKenzie et al. (2008)
◆ Ben-David et al. (2010) ▲ Goldenson and Stoddard (2013)
□ Bar-Yosef and Venezia (2014)



Analysis:

- Experts are overconfident—on average, never identified more than 70% of the range
- Magnitude of overconfidence was inconsistent across studies
 - Would adjusting expert's range to meet a minimum coeff. of variation be superior to utilizing standard 30% rule-of-thumb?



Q2: Elicitation Model

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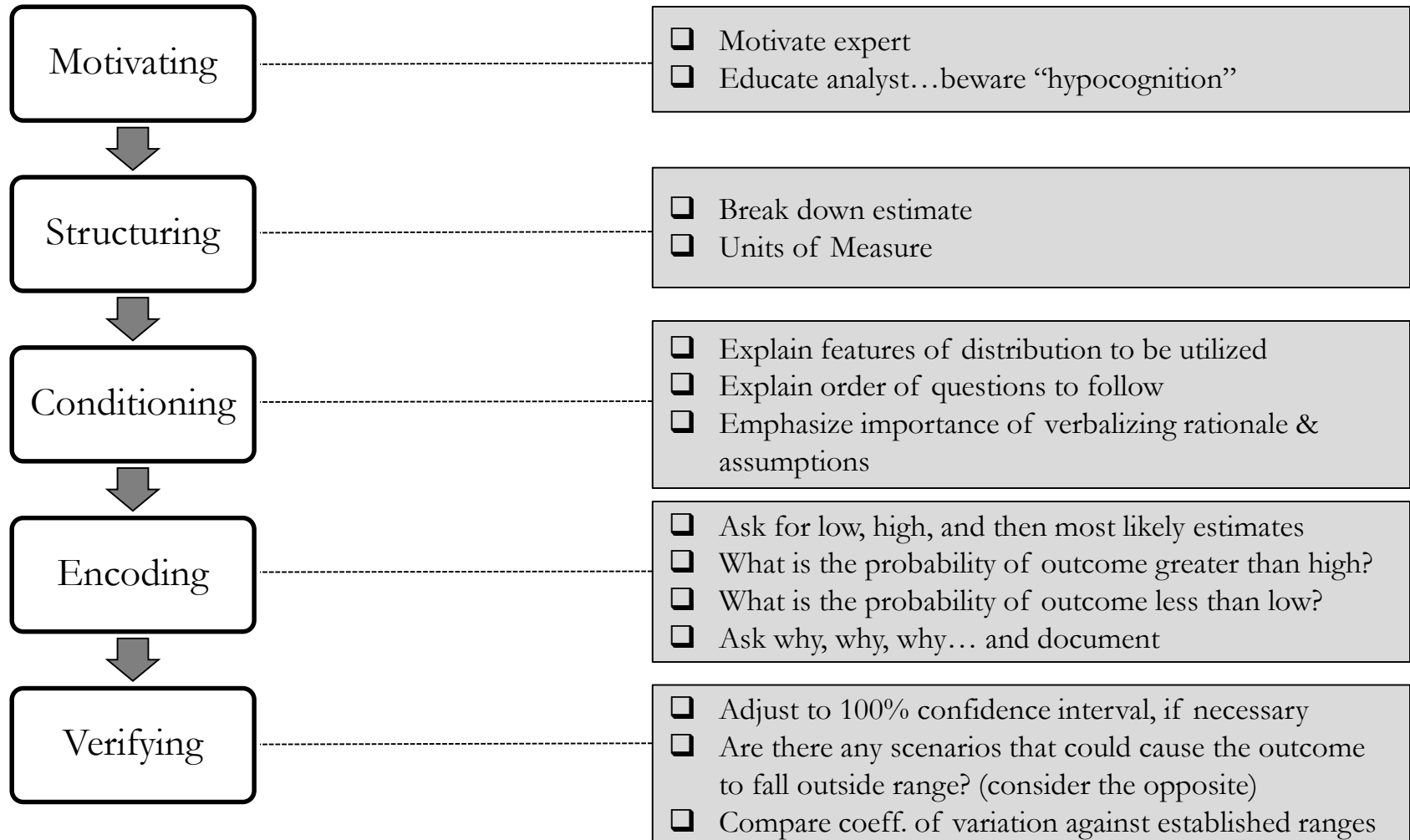
- Based on Stanford Research Institute (SRI) model
 - First proposed by Spetzler & Stael von Holstein (1975)
 - Morgan & Henrion (1990) cite SRI model as most influential elicitation model
 - Model further adapted by this author for cost and schedule estimating
- Five Phases
 1. Motivating
 2. Structuring
 3. Conditioning
 4. Encoding
 5. Verifying





Q2: Elicitation Model

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Conclusion/Recommendations



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- Meta-analysis confirms JA CSRUH heuristic—on average, experts never identify more than 70% of uncertainty range
 - Magnitude of overconfidence is inconsistent—consider adjusting expert's range using coeff. of variation (CV), and not just 30% heuristic
 - Recommended research: produce accuracy and CV ranges specific to estimating modality (parametric, scaled analogy, expert opinion)...underway in AFLCMC
- Recommend adoption of structured elicitation model. Potential benefits:
 - Provides a guide for new analysts
 - Will encourage better documentation
 - More consistent/repeatable/examinable results



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Back-up



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Strategies



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Strategies for decreasing overconfidence:

- Avoid anchoring bias—ask for the high and low outcomes prior to asking for the most likely (e.g. Soll and Klayman, 2004; Speirs-Bridge et al., 2010).
- Allow expert to self-select the confidence level
- If expert struggles, manually walk the expert through the creation of the prediction interval (Teigen & Jorgenson, 2005). For example:
 - “Could the requirement exceed 1,000 hours?”, or
 - “What is the probability that the requirement exceeds 1,000 hours?”.
- Ask “why?”....a lot
- Ask expert to consider why they may be wrong (Herzog & Hertwig, 2009):
 - “Imagine that the true requirement is greater than the upper bound of your given prediction interval. What are a few reasons this could be? What assumptions or considerations may be wrong?”



Elicitation Checklist



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1. Motivating

- ☐ Analyst: Familiarize yourself with the requirement needing expert elicitation. Begin formulating questions, and gather data that may be relevant to the expert.
- ☐ Tell the Expert: The purpose of this cost estimate is to estimate _____ in support of _____.

2. Structuring

- ☐ *Ask the Expert:* Should we break down the estimation of the requirement into smaller components?
- ☐ *Ask the Expert:* Would you feel most comfortable estimating the unknown quantity in person-hours, full-time equivalents (FTEs), SLOC, or another unit?
- ☐ *Ask the Expert:* What ground rules and assumptions are you making about the requirement being estimated?



Elicitation Checklist (cont.)



The AFIT of Today is the Air Force of Tomorrow.

1. Motivating

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Elicitation Checklist (cont.)



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3. Conditioning

- ☐ Tell the Expert: Today I will ask your assistance in constructing the triangular or Beta-PERT distribution that best represents your state of knowledge. I will begin by asking for your low outcome, followed by your high outcome, and lastly I will ask for the most likely outcome.
- ☐ Tell the Expert: Subsequently, I will ask you for the probability (or likelihood) that the costs will be lesser/greater than your estimated low and high.
- ☐ Tell the Expert: When providing your response for low/high/most likely, please explain the assumptions, rationale, mental model, or analogy used to estimate each outcome. This will help us defend the estimate to decision makers, and will be useful if the estimate is later revisited.



Elicitation Checklist (cont.)



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4. Encoding

- ☐ Ask the Expert: What is the low outcome? Why?
- ☐ Ask the Expert: What is the high outcome? Why?
- ☐ Ask the Expert: What is the most likely outcome? Why?
- ☐ Ask the Expert: Could an outcome be less than your low estimate? If so, what is the probability? What scenario could cause this to happen?
- ☐ Ask the Expert: Could an outcome be more than your high estimate? If so, what is the probability? What scenario could cause this to happen?



Elicitation Checklist (cont.)



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5. Verifying

- ☐ Analyst: If the expert responded that the interval had a confidence interval of less than 100 percent, adjust the expert's low and high using JA CSRUH Table 2-8 so that a 100 percent confidence level is reached. These values are the distribution's absolute min and max.
- ☐ Ask the Expert: Are there any conceivable scenarios that could cause the outcome to be less than the minimum? If so, what is the probability? What scenario could cause this to happen?
- ☐ Ask the Expert: Are there any conceivable scenarios that could cause the outcome to be more than the maximum? If so, what is the probability? What scenario could cause this to happen?
- ☐ Ask the Expert: Does the distribution require any further adjustments? Does it best represent your current state of knowledge?
- ☐ Analyst: The elicitation is complete. Thank the expert for their time. Compute the elicited distribution's coefficient of variation (CV), and consider adding 30 percent additional uncertainty if the CV is low (less than 0.25). Note that the expected CV will vary depending on the requirement being estimated and the milestone that the estimate is supporting.